The Isovector Giant Quadrupole Resonance with ^<13>C(γ,n) Reaction(Abstracts of Doctoral Dissertations,Annual Report (from April 1994 to March 1995))

著者	ITO Sachiko
journal or publication title	The science reports of the Tohoku University. Ser. 8, Physics and astronomy
volume	16
number	1
page range	145-146
year	1995-10-17
URL	http://hdl.handle.net/10097/25891

The Isovector Giant Quadrupole Resonance with $^{13}C(\gamma, n)$ Reaction

Sachiko ITO

Laboratory of Nuclear Science

The isovector giant quadruple resonance (IVGQR) is not much known yet, except for heavy nuclei. The resonance energy of the IVGQR is expected as $E_R = 130A^{-1/3}$ or $57A^{-1/6}$ [1]. Although the IVGQR has studied with several probes and the resonance energy has been discussed, no clear discrimination between the two formulae has been made.

Photo-nucleon emittion reactions and their inverse, the radiative capture reactions, have the advantage due to the inherent selectivity of the photon. By measureing the forward-backward asymmetry in angular distribution of reaction products, caused by the interference between reaction amplitudes of opposite parity, one can detect small amounts of E2 (even-parity) strength in the presence of a large amount of E1 (odd-parity) strength.

We have carried out the $^{13}C(\gamma, n)$ experiment in an excitation energy range of $E_x = 16 \sim 69$ MeV by using the tagged photon facilities at the Laboratory of Nuclear Science, Tohoku University. Neutrons following the $^{13}C(\gamma, n)$ reaction were measured by newly developed large-volume liquid-scintillation detectors [2] which were placed at $\theta_{lab} = 55°, 90°$ and $125°$ and at the flight path of 2.5 m. Veto detectors for charged particles are set in front of each neutron detector. Cross sections for the transitions leaving the residual ^{12}C in its $T = 0$ ($E_x = 0.0$ and 4.4 MeV) and $T = 1$ ($E_x = 15.1$ MeV) states were measured separately. The asymmetry (A), defined as

$$A = \frac{[(d\sigma/d\Omega)_{55°} - (d\sigma/d\Omega)_{125°}]}{[(d\sigma/d\Omega)_{55°} + (d\sigma/d\Omega)_{125°}]}, \qquad (1)$$

are obtained and shown in Fig.1.

The calculations of the asymmetries have been made using the direct-semidirect model (DSD) [3], and compared with the data. A computer code HIKARI, which has been developed by Kitazawa [4], was used for the calculations. In order to reproduce the large positive asymmetry, the IVGQR was included and its resonance enrgy (E_R), width (Γ), and fraction of the isovector E2 non-energy weighted sum rule (η) were taken to be $E_R = 30.9 \pm 1.5$ MeV, $\Gamma = 8 \pm 6$ MeV, and $\eta = 0.3 \pm 0.1$ for the transition to T=0 states, where only $T_<$ part of the resonances can contribute. For the transiton to near the 15.1 MeV excited states of ^{12}C, the decay from both $T_<$ and $T_>$ are allowed. The $T_>$ part of the IVGQR were determined as $E_R = 43.2 \pm 1.8$ MeV, $\Gamma = 13 \pm 6$ MeV, and $\eta = 0.6 \pm 0.2$. Weighted average value E_R for the IVGQR on ^{13}C are obtained as $E_R = 39.1 \pm 1.7$ MeV. This supports the systematics of $E_R = 57A^{-1/6} = 37$ MeV, as one can see in Fig.2.

There are only a few of theoretical works concerning with the isospin splitting of IVGQR. Using the schematic model, Kawazoe and Tsukamoto suggested the isospin splitting of the IVGQR as,

$$E_{T+1} - E_T \simeq \frac{T+1}{A}\left(V_1 - \frac{32.0\ [\text{MeV}]}{A^{1/3}}\right), \tag{2}$$

where V_1 is the depth of the Lane potential, $V_1 \simeq 100$ MeV [5]. The splitting for ^{13}C is expected to be 10 MeV, and can reproduce our results, $E_{T+1} - E_T = 12.3 \pm 2.3$ MeV, within the error.

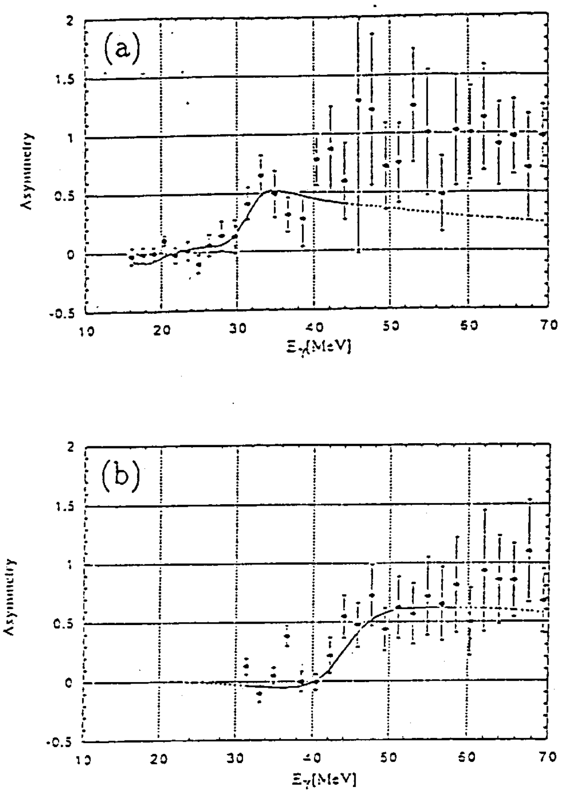

Fig.1 The asymmetries for (a) $T = 0$, and (b) $T = 1$ residual states. Curves are DSD calculations.

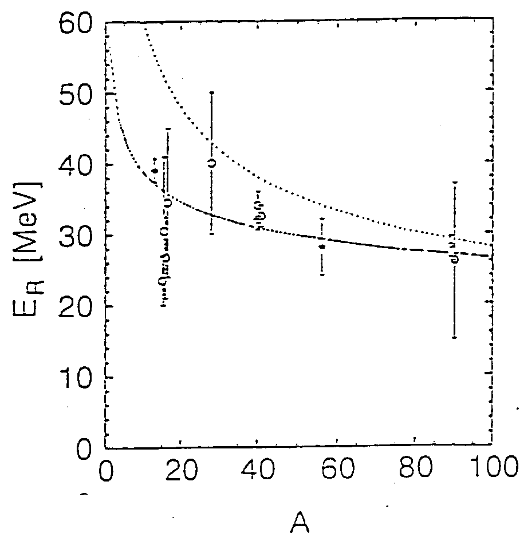

Fig.2 The mass dependence of excitation energies of IVGQR. Solid circles represent our results including ^{56}Fe, and open circles represent previous data. Solid curve represents $E_R = 57A^{-1/6}$, and dotted curve represents $E_R = 130A^{-1/3}$.

References

[1] T. Suzuki, Prog. Theo. Phys. **64** (1980) 1627.

[2] S. Ito et al., Nucl. Instr. and Meth. A **354** (1995) 475.

[3] G. E. Brown, Nucl. Phys. **57** (1964) 339. ; C. F. Clement, A. M. Lane and J. R. Rock, Nucl. Phys. **66** (1965) 273; Nucl. Phys. **66** (1965) 293.

[4] H. Kitazawa, private communication.

[5] Y. Kawazoe and T. Tsukamoto, Phys. Rev. C **23** (1981) 2364.